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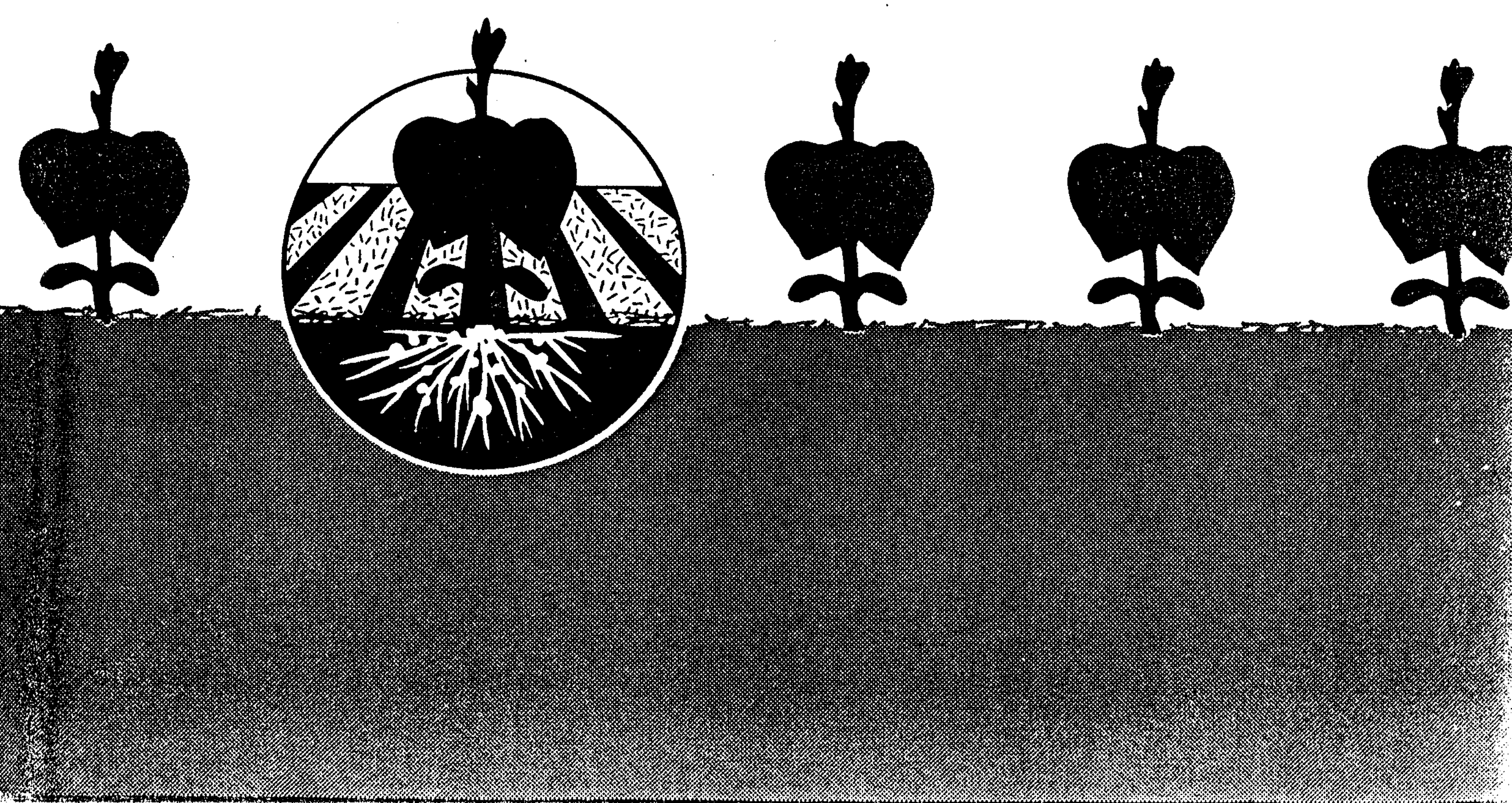
# The role of legumes in conservation tillage systems

J. F. Power, editor



# Effect of soil surface color on soybean seedling growth and nodulation

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Spectral composition of light, especially in the blue, red, and far-red regions of the spectrum, acts through photoreceptors within the growing plant and functions in natural bioregulation of physiological processes to control growth and development (*2, 3, 4, 9, 10*). For example, the far-red relative to red ratio, acting through the phytochrome system in the developing plant, can regulate chloroplast ultrastructure (*5*); photosynthetic efficiency (*3*); and partitioning of photosynthate among leaves, stems, and roots (*7*). Also, blue light regulates some physiological responses, such as stem length suppression (*10*). Subtle differences in quantity and quality of light reflected from different colored soils can alter seedling environment sufficiently to affect establishment and early growth of soybeans. This might contribute to differences in seedling establishment between bare- and plant residue-covered seed beds, as has been noted among various geographic areas (*1, 8*) with different soil colors.

Table 1 shows the variation in the spectral composition of light reflected from soil surfaces (*6*). These measurements were made with a LiCor spectroradiometer at a height of 10 cm above the soil surface. The photosynthetic photon flux density values of reflected light decreased as follows: white > red > black. Crop residue cover modified the quantity of reflected light. For example, residues over dark soils more than doubled the photosynthetic photon flux density, whereas residues over gray-white soils decreased the quantity of reflected light. Far-red/red light ratio differences over the various colored soils and residues were small. However, the reflected blue light was much greater over the light colored soils than over the dark colored ones.

We investigated the effects of surface color on soybean seedling growth in a greenhouse study. White, red, and black soils were placed to a depth of 2 cm on a 1-m$^2$ plywood box. The plants grew through tubes that were inserted through the soil box into growth containers attached to the bottom of the boxes. We altered the air flow beneath the black soil boxes enough to make root zone temperature of the black-soil-surface treatment similar to those of the other treatments even at peak temperatures.

Leaf area, tap root weight, and nodule number were not signficantly affected by soil surface color. Total shoot weight and leaf weight were greater for plants grown over white soil compared with the other surfaces (Table 2). Stem weight and leaf weight/area were greater for plants grown on the straw-residue-covered soil and white soil than on the red or black soils. However, residue-covered soil surfaces affected stem length differently than white soil. Plants in the residue-covered soil were the tallest, and plants on the white soil were the shortest. Plants grown over white soils had much greater weights of lateral roots than plants grown over the black, red, or residue-covered soils. The weight of lateral nodules on plants grown over white soil also was significantly greater than those of plants grown over the other surfaces. Plants grown over the white soil surface had a lower shoot:root ratio than plants grown over the residue-covered soil.

Plant growth was significantly altered by the soil surface color even though root temperatures as well as moisture and nutrition were not significantly different for the different surface color treatments. We could not consistently relate the grouping of plant growth responses to the total reflected light, blue light enrichment, or far-red/red ratio. These observations suggest that the measured growth parameters were sensitive to different aspects of reflected light. The quantity and spectral distribution of reflected light that would be best for plant growth and yield in a particular environment would vary

**Table 1. Light reflection upward to a point 10 cm above the soil.**

| Light Parameter and Soil Color | Soil Surface Dry | Wet | Under Residue Corn |
|---|---|---|---|
| Photosynthetic photon flux density (μmol/m²/s)* | | | |
| Black | 82 | 65 | 161 |
| Brick-red | 164 | 114 | 189 |
| Gray-white | 355 | 261 | 217 |
| Far-red/red ratio relative to ratio in direct sunlight | | | |
| Black | 1.15 | 1.10 | 1.19 |
| Brick-red | 1.18 | 1.23 | 1.21 |
| Gray-white | 1.09 | 1.14 | 1.19 |
| Blue (400 to 500 nm) as percent of blue in direct sunlight | | | |
| Black | 5.2 | 4.4 | 8.0 |
| Brick-red | 6.6 | 5.6 | 8.9 |
| Gray-white | 20.8 | 15.0 | 11.4 |

*Flux density of direct sunlight was 1,670 μmol/m²/s.

**Table 2. Shoot and root growth and nodule characteristics of soybean seedlings grown over different colored soils in a greenhouse.**

| Plant Parameter | Soil Surface Color: White | Red | Black: Bare | Black: Residue Covered |
|---|---|---|---|---|
| Shoot | | | | |
| Leaf weight (mg) | 289a | 234b | 224b | 238b |
| Leaf denisty (mg/cm²) | 2.1a | 2.0b | 2.0b | 2.1a |
| Stem length (cm) | 12.6c | 13.9bc | 14.1b | 15.9a |
| Stem weight (mg) | 137a | 120b | 120b | 136a |
| Root | | | | |
| Tap length (cm) | 16b | 19a | 18a | 18a |
| Lateral weight (mg) | 220a | 151b | 161b | 156b |
| Tap:lateral weight ratio | .18b | .27a | .26a | .25a |
| Total weight (mg)† | 293a | 213b | 222b | 217b |
| Lateral nodule weight (mg) | 29a | 17b | 17b | 19ab |
| Shoot:root weight ratio | 1.49b | 1.69ab | 1.57ab | 1.75a |

*Means on the same line followed by the same letter are not significantly different by the LSD test at the P level of 0.05.
†Total root weight includes nodules.

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with management. Thus, a better understanding of the effects of soil color on seedling establishment is needed to capitalize on potential benefits for conservation tillage, crop production, and resource management.

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